REPAIRING TRANSISTOR RADIOS

V. CAPEL

PART 1

THE cheap transistor radio can often pose something of a headache for the professional engineer. All repairs take time, and sometimes an elusive fault can take more time than a straightforward fault on a television receiver. The situation is aggravated by a lack of service information and spares where, as is more often than not, the radio is imported. A repair bill can result which is a large proportion of the original cost of the set, and the owner naturally thinks he is being had.

Because of this, many dealers understandably refuse to accept these cheaper radios for reepair. Amateur repairers not having to make their time pay may agree to have a go, often later to wish they had not!

In general, it is prudent to set a time limit of say a quarter of an hour and if the fault cannot be located in this time, the set should be returned to the owner as being beyond economic repair. This calls for quick, short-cut methods of diagnosis and repair, some of which may be frowned upon if used with conventional equipment, but which in many cases would be the only alternative to refusing the repair. We should add that these remarks do not apply to the better class transistor radio which is backed by spares service and technical information. These should, of course, be serviced in the normal way.

A common fault is for the receiver to be completely dead. While in theory a number of things could be responsible, in practice a few faults crop up with almost monotonous regularity, so these can be checked first.

Batteries that have been left in cause corrosion of the contacts which of course remains when the owner fits new batteries. Often the trouble is nothing more than poor battery contact due to this cause. The remedy is obvious.

Another very common source of trouble is the on/off switch. Generally an integral part of an edge-type volume control, they are impossible to repair economically and the only course is to fit a complete new control. Fortunately, the value of the volume control seems to be standardised at 5kΩ, and a number of component firms make controls that will fit. The main consideration is physical size, if too large it will jam in the case aperture, and if too small, will not reach far enough through. The disposition of the contacts may not line up with the original on the printed panel but this can usually be overcome by bending some of the contacts and soldering a section of copper wire to those that may not reach. A few controls have the switch mounted externally in which case a repair can often be made by adjusting the switch contacts.

A quick test can be made on both battery contacts and switch by taking a voltage reading at some convenient point on the print, from an earth point, say one of the coil screening cans to one of the tags on the output or driver transformer. This should show almost full battery voltage, if it is much less, there is a high resistance in series, possibly corroded battery contacts or faulty switch.

Correct voltage measured here means we must look further. Scratching the volume control terminals with the meter probe and the meter switched to the ohms range should produce crackling in the loudspeaker, and if so, suggests that the fault is in preceding stages. No crackling means trouble in driver or output circuit. Open-circuit loudspeaker speech coils are not at all uncommon, especially the higher impedances, so this is worth checking next; failing this, check earphone socket shorting contacts.

MECHANICAL DAMAGE

Often the radio has been subject to a fall and a frequent result is that the output or driver transformer is partly wrenched from its position in the print. A casual glance may not indicate this but sometimes one or more of the fine wires coming from the windings are broken away from their terminal posts. Whenever there is trouble in this end of the set, it is always worthwhile to make a visual examination of the transformers, especially the lead-out wires.

If the set is lively from the volume control onwards, flicking the waveband switch may produce clicks, which would suggest that the i.f. stages are working and that the mixer and r.f. stages should be investigated first. It is still possible for the i.f. stages to be at fault, but the odds are on the previous ones.

If the trouble appears in the first stage it is wise to check the connections to the ferrite aerial coils. The rod is not always rigidly mounted, and any mechanical shock could easily strain the fine wires from the coils to the print. In many cases these wires are left long enough by the makers to facilitate adjustment by sliding along the rod, but this slack may already be taken up by a previous alignment. Broken aerial wires are very common and can give rise to several faults. Complete lack of signals is one, where the broken lead is common to both wavebands or as is sometimes the case, where there are more than one broken. Often it leaves one waveband dead and sometimes produces a rather puzzling symptom of breakthrough from one band into the other. Thus the light programme on 1500 metres is superimposed on the BBC London or Welsh Home service.

A close look at the components mounted on the printed panel would not come amiss. Look for vertically mounted parts that are leaning over at an angle, suggesting they may have been forced and either damaged or pulled from their printed connection. Components mounted near the battery compartment are particularly prone to this sort of trouble by suffering from the attempts of a ham-handed owner to replace the batteries! A probe at any likely looking suspect with an insulated tool will confirm the suspicion.

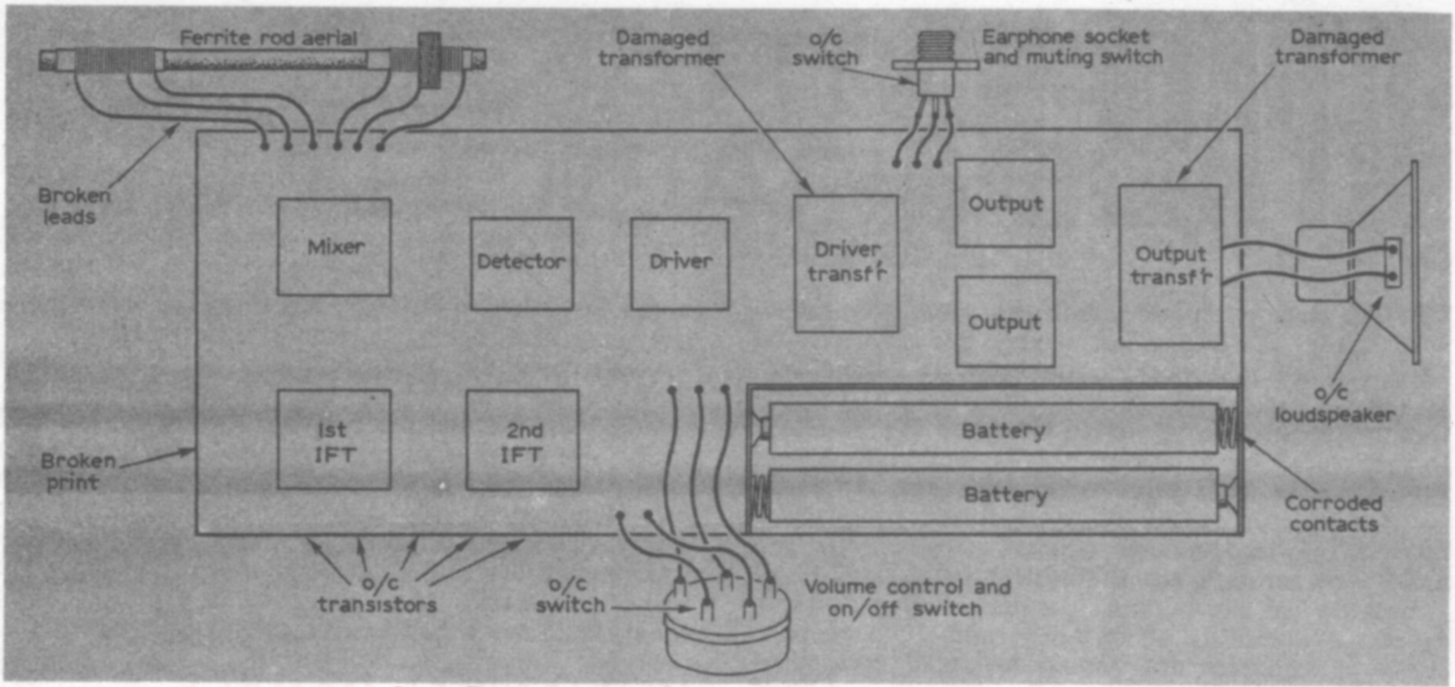

Fig. 1: The most common faults in a normal a.m. transistor radio.

The rough tests we have described followed by a visual check of the suspected part of the circuit will take just a matter of a few minutes. Many faults will come to light by this means. Remember that a large proportion of troubles with portable transistor radios are mechanical in origin.

Next, after these checks, the most likely possibilities to investigate are printed circuit faults or defective transistors. This is where the meter must be used again and voltage measurements taken. We will have already roughly isolated the section of the receiver in which the trouble lies, so now collector, base and emitter voltages of transistors within that section can be measured. If service information is not to hand, exact readings cannot be compared with correct figures, however in most cases defects can be quickly spotted.

Collector voltages are generally not less than about three-quarters of the battery voltage except in audio stages where the collector is directly coupled to the base of the following stage. Where two batteries or a tapped battery is used, the full voltage is often only applied to the output stage and perhaps the driver, the rest of the circuit being supplied from one battery or section.

Base and emitter voltages vary considerably according to the circuit from a few tenths of a volt to over one volt. The main thing is to compare the base voltage with the emitter. Assuming germanium p-n-p transistors, the base must be slightly more negative than the emitter, so a difference of one or two tenths of a volt should be measured. A higher base voltage could be due to an internal leak or an open-circuit bottom bleeder resistor to the base. A low base voltage could indicate an open-circuit top resistor. No emitter voltage is the result of an open-circuit transistor, unless of course the emitter has no series resistor. A high emitter and base voltage with a low collector voltage betrays excessive current due to internal leakage.

Some confusion can result when taking voltage readings as to which point to measure from, as some sets have positive earths and others negative. It is usually the most straightforward practice to ignore the earth and to clip the positive lead of the meter to the battery positive terminal taking all readings from there.

If a transistor appears to be at fault, it is not always necessary to remove it in order to try a replacement. This takes time, and more time is wasted re-fitting it if it is not the trouble, to say nothing of possible damage by soldering (it is usually impossible to use a heat sink). In most cases, just connect a substitute in parallel with the suspect, on the print side of the board and without cutting the wires. If the set works, then the old one can be removed and the replacement fitted properly, if not, little time is wasted. The old one seems to have little effect on the working except where it is drawing excess current. In such case, just disconnect the collector wire.

Many imported sets use transistors with type numbers that mean little to the average engineer. An equivalent list is very handy if available. If not.

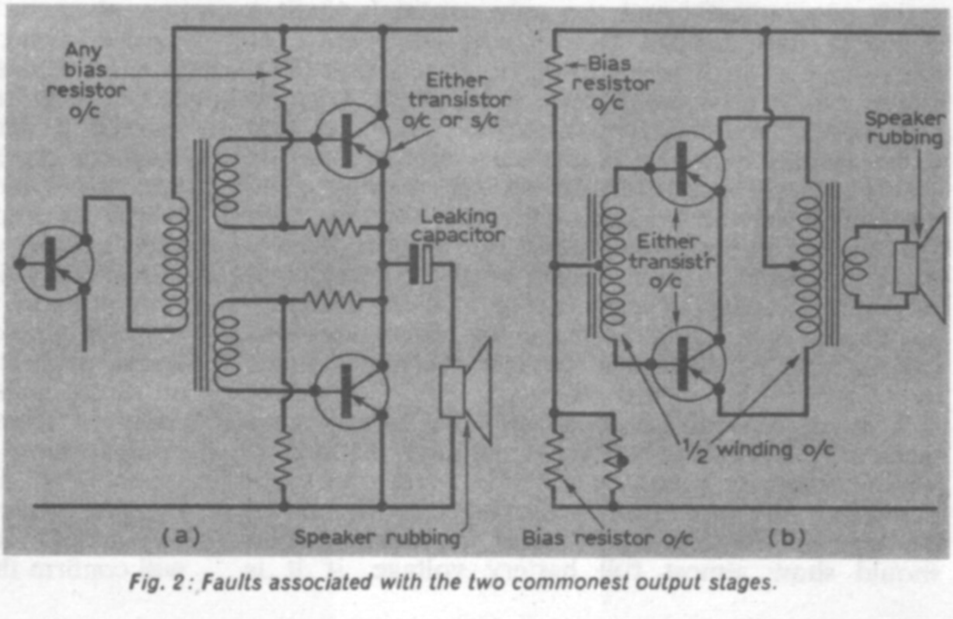

Fig. 2: Faults associated with the two commonest output stages.

or if the type is not listed, then fit anything which is in the same class (mixer, r.f., a.f. or output). Unlike valves, transistors have a high degree of compatibility and in the field of the cheap portable radio, any minor differences in performance are unimportant, it might even be better than the original! Certainly it is uneconomic to spend time trying to chase exact equivalents even if there are such. The output stage is the only one where some thought may have to be exercised in choosing a replacement, and alteration of the base forward bias may be required. After replacing such, check for distortion and that the quiescent current is reasonable for the type of set.

This brings us to perhaps the most troublesome and frustrating fault to locate, print faults. These may be dry joints between print and components or hair-line cracks in the print itself.

Bending and flexing the panel will often make the fault come and go although not necessarily indicate where it is. Gentle prodding around will sometimes bring it to light, but not always. Another way of tackling the trouble is to take a voltage reading around the suspected area, then flex the panel to see if there is any change in value. This can be repeated at various points, and any change discovered followed up through connecting print and components.

DISTORTION

Another very common complaint is distortion. In by far the majority of cases, the trouble is in the output circuit, so diagnosis should not take so long as with some other faults. First of all though, check the battery voltage. Even if it is claimed to be a new battery, it could have been left switched on when not in use, not an uncommon occurrence.

The usual source of trouble is failure of one half of the push-pull output pair. If the series configuration is used, take voltage readings to find if the collector of the bottom transistor and the emitter of the top one are about half of the battery voltage. If this mid-point is in fact either higher or lower by any marked extent from the half value, most likely one of the transistors is either open-circuit or partially so, or has a high leakage, depending on whether the voltage is high or low and which transistor is defective. The quickest and cheapest course is to replace both transistors. Before doing so though, just check the base-bias resistors, and take another measurement with the speaker disconnected. The capacitor feeding the speaker may be leaky and cause an abnormal voltage reading, disconnecting the speaker will remove the leakage return path and restore correct voltage if this is the cause of the trouble.

If the output stage is of the normal transformer push-pull type, voltage readings will not be a great help. Defective transistors will not have a great effect on voltage because of the low series impedances. Voltages should be measured of course, to make sure that bias is present and the output transformer windings are continuous. If these are in order, the quickest way of checking the transistors is to short the base to emitter of each in turn with a screwdriver blade. When both transistors are working correctly, the result will be distortion and a drop in volume. Shorting a defective one will have little or no effect, while shorting its companion will stop the set working completely or nearly so.

Thus the faulty transistor can be quickly located and replaced. Discretion can be used as to whether it is deemed necessary to replace the other as well. If only one is replaced, then the replacement should be of the same type.

A frequent cause of distortion is the loudspeaker. Trouble is due to the speech coil rubbing the pole pieces of the magnet. This is not always easy to identify as it can sound very much like distortion originating in the output stage. It is usually worse at low volume settings, because the rubbing tends to be masked at higher volumes. Often it can be felt by gently pushing the cone in and out with the finger tips, but this is not always decisive. Hooking up another speaker is the best test. Impedance is not too critical, a 3-ohm can be used in place of an 8-ohm for testing, but a series resistor should be used in a 30-ohm circuit. A 15-ohm speaker is very useful for bench testing if one can be acquired, as it can be used with almost any circuit.

Distortion can be traced to other causes than the output circuit. The driver stage can be responsible and even the pre-detector stages. These however are rarer and will have to be tackled by voltage measurements and other conventional servicing techniques.

TO BE CONTINUED

I.C. OF THE MONTH

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★ components list

Resistors

R1	820 Ω	R7	15k Ω
R2	390 Ω	R8	10k Ω
R3	8·2k Ω	R9	100 Ω
R4	8·2k Ω	R10	180 Ω
R5	1k Ω	R11	27k Ω
R6	680 Ω		

All resistors, ¼watt, 10% types
VR1 5k Ω pot. with switch
VR2 100 Ω preset pot.

Capacitors

C1	0·1μF	C8	0·05μF
C2	0·05μF	C9	0·22μF
C3	0·05μF	C10	0·001μF
C4	0·22μF	C11	0·001μF
C5	10μF 6V	C12	320μF 12V
C6	0·05μF	C13	32μF 12V
C7	200μF 12V		

VC1, VC2 208pF + 176pF ganged tuning capacitor.
TC1, TC2 trimmer capacitors associated with above

Semiconductors

TAD100	Integrated circuit
Tr12	AC127
Tr13	AC128

Miscellaneous

L1, L2, medium aerial on ferrite rod suitable for 208pF tuning with secondary; T1, oscillator coil Weyrad type P50/1AC; I.F. filter type LP 1175; THI, VA1077; Loudspeaker 15 Ω type.

The sensitivity of the receiver is very good giving a performance comparable to an equivalent eight transistor quality receiver using conventional discrete components. In addition the TAD100 integrates the major portion of the set providing a far more reliable and rugged receiver. ■

REPAIRING TRANSISTOR RADIOS

PART 2

V. CAPEL

IN the last part we saw that speed is essential in repairing the cheaper transistor radios if an economic job is to be done. Whatever short cuts may suggest themselves in diagnosis and repair should be used even though these may not always be considered to be good practice with more conventional jobs.

Distortion and no-signal faults were dealt with, but now we will consider the symptom of low sensitivity. Almost any stage could give rise to this, but rarely the output stage as faults here generally produce distortion as well. Before getting too involved though, as with other faults, always check the battery first. Although more usually producing distortion, many modern circuits allow the battery voltage to fall to quite low levels before distortion sets in, but sensitivity is bound to suffer.

A quick check can be made by detuning the set and turning up the volume full. A fairly strong background hiss would suggest that the audio circuits were in order and that the trouble probably lay in an early stage, the mixer or the first i.f. A too silent background would indicate that the fault was in the latter stages.

The most usual causes of low sensitivity are mechanical damage, faulty transistors or misalignment. Of the first, a broken ferrite rod is perhaps the most frequent example. A visual examination will soon reveal this. When replacing, make sure that the diameter is the same as well as the length.

In cases where the ferrite rod has broken free from its mounting not only can the fine connecting wires be broken away from the print as described in the previous issue, but the coils themselves can sustain damage. The long-wave coil, being layer wound often suffers with other sharp components digging in and penetrating several layers. This may cause a complete open-circuit or a short-circuit of several turns. This short can be reflected into the medium wave windings and cause low sensitivity on both bands.

Faulty transistors can be diagnosed by voltage readings and shunting a replacement across the suspect as described before. Some idea as to the operation of the i.f. stages can be obtained by detuning each i.f. transformer in turn. There should be a sharp tuning peak in each case with the possible exception of the last one which may be damped by the detector. If it is possible to rotate the core with very little drop in volume, then the associated stage would appear to be faulty. Sometimes a stage may be completely inoperative yet low-volume results can still be obtained due to stray coupling from a preceding stage. Thus the signal 'jumps' the offending stage. Where a good peak is obtained, there is unlikely to be a fault in that part of the circuit. Restore each coil to its correct tuning point before dealing with the next.

Coming back to the ferrite rod aerial again, the aerial coils may simply be loose on the rod and therefore out of their optimum position. Aligning and sealing will bring back the sensitivity to normal.

Mis-alignment can come about in many ways. Portable radios are obviously subject to more shock and stress than others, hence there is plenty of opportunity for coils to become loose and slip as well as coil cores to turn. If the few quick checks we have outlined here fail to come up with the answer, try re-aligning. Not only may an alignment cure the trouble, but if a circuit fault exists, aligning will often reveal it, as something does not tune up which should do.

Conventional alignment procedure calls for the use of signal generator and output meter, but the simple circuits we are dealing with here do not require these. As we have seen, speed is all important and it is quite possible to do an alignment in just a few minutes without wasting time setting up an array of equipment, by using broadcast signals and the ear. Results are little inferior to those obtained when doing it 'properly', if at all.

ALIGNMENT

As with more conventional methods, the first step is to align the i.f.'s. A broadcast transmission should be chosen that is weak in order to avoid a.g.c. action, but it should be steady. One of the more distant BBC Home services will usually serve the purpose. Volume should be turned down to a fairly low level as the ear is more sensitive to volume changes at lower levels.

It can be assumed that the i.f. coils are already near the correct i.f. frequency, or perhaps all except one that has been affected by a fault condition which is now cleared. If it is suspected that all or most of the coils are some way out, as would be the case if the receiver had been tampered with, then a signal generator would have to be used to align to the correct i.f. frequency.

Normally though, the broadcast signal can be used. So starting with the last i.f., the cores are tuned for maximum volume. With a weak station there will be a background hiss due to the local oscillator, and as this is steady, it is often easier to listen to this for making the adjustments rather than the programme content which of course will be varying.

In most cases all i.f. coils will be peaked, but there are some that are stagger tuned. These are usually in the better type of receiver, and stagger tuning is rarely if ever found in the types we are discussing. If stagger tuned coils are peaked, then instability will most likely result. The adjustments should be repeated, especially if it was found that one coil was some way out of tune.

Now we come to the oscillator. Circuits differ widely at this point, but with the simpler portable, differences are not so great as to affect alignment much. Most circuits employ a single oscillator coil

QUICK ALIGNMENT SEQUENCE FOR RADIOS WITHOUT L.W. OSCILLATOR TRIMMER

Tune to:	Adjust:
Weak m.w. station	3rd i.f. transformer for max. volume 2nd i.f. transformer for max. volume 1st i.f. transformer for max. volume then repeat procedure.
Radio 2, 1,500m. Radio 3, 464m. BBC West, 206m. or Radio 1, 247.	Oscillator coil for compromise dial setting Oscillator gang trimmer for correct dial setting then repeat procedure
Weak l.w. station	L.W. aerial coil for max. volume
Radio 3, 464m. or nearby weak station BBC West 206m. or nearby weak station	M.W. aerial coil for max. volume Aerial gang trimmer for max. volume then repeat procedure

QUICK ALIGNMENT SEQUENCE FOR RADIOS WITH L.W. OSCILLATOR TRIMMER

Tune to:	Adjust:
Weak m.w. station	3rd i.f. transformer for max. volume 2nd i.f. transformer for max. volume 1st i.f. transformer for max. volume then repeat procedure
Radio 3, 464m. BBC West, 206m. or Radio 1, 247m.	Oscillator coil for correct dial setting Oscillator gang trimmer for correct dial setting then repeat both procedures
BBC 2, 1,500m.	L.W. Oscillator trimmer for correct dial setting
Weak l.w. station	L.W. aerial coil for max. volume
BBC 3, 464m. or nearby weak station BBC West, 206m. or nearby weak station	M.W. aerial coil for max. volume Aerial gang trimmer for max. volume then repeat procedure

for both wavebands. As it stands, it works the medium waveband, and for the long waveband an additional capacitor is switched in. In some cases a trimmer is switched in as well, and the alignment procedure depends on whether this trimmer is present or not.

The first thing to do then, is to look for a trimmer apart from the two appearing on the gang tuning capacitor. Sets having a bandspread medium waveband in addition to the normal medium wave, will have extra trimmers in which case they will have to be identified. This can be done by giving each a slight turn back and forth and seeing which band is affected. Oscillator trimmers tune sharply whereas aerial trimmers are flat.

Going back to the straightforward two-waveband job, if the separate long wave trimmer is present, we start with the medium wave. Tune in a station at the low frequency end of the scale (gang at maximum capacitance), the Third programme on 464 metres is suitable. Adjust the oscillator coil core to bring the station to the correct point on the scale. Now tune to the other end of the band and tune in a suitable station, the West Home Service on 206 metres or Radio One on 247 metres. Adjust the oscillator trimmer on the gang for correct scale calibration. Repeat both adjustments if necessary.

Switching now to the long wave, tune in the Light programme on 1500 metres and adjust the long wave trimmer.

If there is no long wave trimmer, we start on the long wave. Tune in the Light programme and adjust the oscillator coil core to give correct scale reading. Then we switch to the medium wave and check that the Third programme or other station at the l.f. end comes in the right place. If it does not, the coil is adjusted to give a compromise between the two. With this type of set, scale markings are not very precise purposely. Next the h.f. end of the medium wave is aligned using the West programme or Radio One with the oscillator gang trimmer as in the previous case. A check will then have to be made on both l.f. end of medium wave and long wave and a re-adjustment made if needed. In practice, it will be found that the gang trimmer has very little effect on the long waveband.

Finally, the aerial circuits are lined up. Weak stations are best for this, if the ones used for oscillator alignment are weak they can be used, but if not, others nearby should be found. On the long wave, all that is required is to slide the long wave aerial coil (the largest, most likely layer wound) along the ferrite rod for maximum volume. The medium wave is aligned with the medium wave aerial coil at the l.f. end, then the aerial trimmer on the gang capacitor is used to line up the h.f. end. It is useful to remember that with both oscillator and aerial circuits, induction is used to tune the l.f. and capacitance to tune the h.f. end of a waveband.

All that is needed now is to seal the coils on the rod by melting wax over them and so complete an economical repair. ■

CQ!CQ!CQ!CQ!

ISSUES WANTED

...any issues of P.W. containing circuits, constructional articles on electronic musical instruments, particularly the P.W. Electronic Organ published in the 1950's.—D. E. Bray, 104 Fulmerston Road, Thetford, Norfolk.

...October 1966, November 1966 and all the issues of P.W. that had information on the RAE (1964'65).—C. J. Bourne, 111 Woodhouse Lane, Bishop Auckland, Co. Durham.

...October 1962 issue of P.W. containing part 2 of the Tudor valve receiver.—M. J. Dorby, 266 Canley Road, Coventry, Warwickshire, CV5 6AP.

...the following issues of P.W.: Jan./Dec. inclusive 1964. Jan./Aug. inclusive 1965 Nov./Dec. inclusive 1965. Jan./June inclusive 1966. August 1966. Also the following issues of P.E.: Jan./Oct. inclusive 1966. Dec. 1966. Jan., Feb., April, May and July/Dec. inclusive 1967. All preferably including blueprints.—D. L. Edwards, 18 Parkdale Crescent, Worcester Park, Surrey.

...January 1967 issue of P.W. containing Explorer Rx.—S. Marklew, 4A George Street, Wombwell, Nr. Barnsley, Yorks.

...the periodical with the article about the conversion of WS 38 to top band.—Alan Carter, Rosemary, Shakespear Avenue, Langdon Hills, Basildon, Essex.

...June 1965 issue of P.W.—N. Taylor, 21 Tower Mill Road, Millfield Estate, Bungay, Suffolk.

...April 1966 issue of P.W. dealing with mods to the 19 set.—Thomas Smith, 50b Aldershot Road, Guildford, Surrey.

...July 1963 issue of Practical Wireless and the September 1967 issue of Wireless World.—S. Saethern, Box 336, N-3101 Tonsberg, Norway.

...the issue of P.W. containing the article on the Colour Organ.—4269206 S.A.C. Swift D.G., 'B' (S.C.S.) R.A.F. Stanbridge, Leighton Buzzard, Beds.

...the issue of P.W. containing E. J. Wotton's t.r.f. receiver. I think it was February 1961.—V. Reed, 25 Aclington, Ashford, Kent.

...the issues that covered the article on the 19 set conversion for 1.8 to 2MHz.—B. W. F. Mainprise, Vine Cottage, Exminster, Exeter.

...the September 1957 issue of Practical Wireless and the circuit diagram of the 266 indicator unit.—Paul Dornington, 383 Spen Lane, Leeds, 16, Yorks.

...October and November 1964 issues of P.W.—John McGregor, 20 Lorton Close, Mirehouse, Whitehaven, Cumberland.